

Control of Invasive Aquatic Weeds in the San Francisco/ San Joaquin River Delta and their Long-term Management in Critical Habitats, Recreation Areas and Conveyance Systems
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Exotic and invasive aquatic plants are problematic throughout a large portion of the San Francisco-San Joaquin River/ Bay Delta. In freshwater areas, these weeds include fully submerged, floating and emergent plants such as, Brazilian waterweed (*Egeria densa*), water hyacinth (*Eichhornia crassipes*) and Uruguayan primrose-willow (*Ludwigia hexapetala*), respectively. Additional invaders, such as Eurasian watermilfoil (*Myriophyllum spicatum*), South American Sponge Plant (*Limnobiium laevigatum*) and giant reed (*Arundo donax*), often fill similar niches in the Delta but are not yet as problematic. Their infestations are currently observed at lower densities than the primary weed pests, however they represent an on-going threat that also must be effectively managed along with other new weeds. Regardless of the species of invasive weed, these plants are highly detrimental economically, environmentally and sociologically in the Delta, and severely impact its many uses. In some areas of the Delta, water hyacinth and Brazilian waterweed grow so dense that they physically block waterways and often inhibit navigation of recreational boats and larger commercial ships. These weeds also create problems in water conveyance systems, clogging screens, damaging pumps, blocking canals and thus negatively affecting the redistribution of water resources for both agriculture and for domestic water use. They further disrupt the biology and ecology of the Bay, impinging beneficial species that normally provide the bases for the Delta food web. In doing so, they threaten many of our native and beneficial plants and animals including highly threatened fish such as Chinook salmon and steelhead trout. More directly, they alter habitats by blocking light, changing water chemistry and oxygenation that make affected waters uninhabitable for many important species of fish. In addition, emergent invasive plants such as giant reed physically affect the Delta by invading levees and accelerating their degradation by undermining the structural integrity of protective berms through root growth and increased erosion.

To date, the management of these weeds has been limited by: 1) short-term planning and sporadic/ temporary funding, 2) an overall lack of human and monetary resources, 3) extensive regulatory rules and treatment limitations/ periods, and 4) no wide-area management plan capable of targeting these weedy plants at appropriate geographic scales to achieve regional long-term suppression. The affect of the current approach to aquatic weed management is localized control that is often conducted in near-crisis mode, with weeds only being targeted and suppressed when densities grow far beyond acceptable levels. Recognition of these invasive weed problems was only briefly addressed in the recently published Bay Delta Conservation Plan (2013, see Other Stressors, CM13, Invasive Aquatic Vegetation Control), where the primary means of weed management is listed to be spraying chemical herbicides into infested areas. Chemical herbicide application is no doubt a key element to successful weed control but more holistic invasive plant management strategies are needed or Delta managers will remain on what is commonly referred to as a pesticide treadmill. In fact, many planned restoration projects in the Delta are doomed to fail before they begin unless a more comprehensive means of managing invasive aquatic weeds is developed and implemented from the start of restoration efforts.

Up until 2014, the CA Department of Boating and Waterways (now the Division of Boating and Waterways (BWWs) within California Department of Parks and Recreation) was required to obtain annual Federal Permits provided by the DOI-US Fish and Wildlife Service and the NOAA-National Marine Fisheries Service. In 2014, these two Federal Agencies agreed that longer-term permits would be helpful in planning and implementation of more sustainable weed management programs and thus a multi-year permitting process was agreed upon. With this agreement the Agencies requested a more holistic and comprehensive approach to invasive weed control in the Delta be developed. To aid in this longer-term permitting and planning, BWWs sought the assistance of the USDA-Agricultural Research Service, who agreed to serve as their Federal nexus in the environmental assessment and regulatory process. Based on this cooperative effort, the regulatory agencies approved treatment permits over a 5-year period for three critical invasive weed species (*E. densa*, *E. crassipes*, and *L. laevigatum*). While this regulatory milestone is significant and will expedite annual treatments, it also stimulated additional planning and implementation of more holistic research and developmental plans aimed at longer-term

sustainable approaches to invasive weed management in the Delta. These will include but are not limited to, a more thorough assessment of the impact of these invasive species on threatened, endangered and other beneficial species, an assessment of the weeds' growth habits under the diverse conditions in the Delta, and new means of assessing and controlling these plants in different habitats. Most importantly, it was requested to determine if replacement seeding or propagation of native plant species might inhibit or delay reinfestation of critical habitats from these weeds in the future. More effort was also proposed to develop and implement sustainable methods of control rather than depending so heavily on chemical pesticides. For example, biological controls have been used effectively for some of these weeds, in different parts of the country and other locations all around the world. Initial attempts at biological control of water hyacinth in the Delta, however, have not been successful, although the reasons for this failure are unknown at this time. Future investigations need to assess why such biological control agents are not well established in the Delta and if there are reasonable ecological means of overcoming limitations. New biological control agents for other Delta weeds also must be developed.

Additional area-wide monitoring, weed growth and movement predictions and overall impact assessment of weed infestations need to be conducted so that ground- and water-based managers have a more complete understanding of weed infestations throughout the Delta. The use of remote sensing and GIS mapping/modeling will allow better targeting of weed populations in ways that contain weed population growth and restrict their movement, thus limiting establishment in new areas. Critical habitats need to be identified, prioritized and protected against these invasive species to optimize the use of program resources and to maximize protection to both humans and the environment. Both economic assessment and environmental impact assessment are required to aid in this process. Additionally, the association between these invasive weeds, native plants, mosquitoes and other arthropods that support the Delta food web need to be better understood and targeted for study. We no longer can afford to just kill aquatic weeds in the Delta. We now must learn to develop and implement overall Integrated Vegetation Management programs that not only eliminate weeds, but also transform critical parts of the Delta into more desirable and sustainably productive areas with multiple uses. If managed in an appropriate fashion, the weeds themselves could potentially have some desirable characteristics and might be used to sequester nutrients from the water or serve as nursery sites for certain biological control agents that could be effectively used in other areas of the Delta. To accomplish such goals, a comprehensive research and implementation team needs to be established and directed to develop a detailed action plan to enhance weed management activities over the next decade. This will involve understanding the factors that are currently driving weed infestations and discovering methods of limiting their growth and impact, along with the development and implementation of improved habitat management for beneficial species and purposes.

Recommendations:

- 1) Establish and empower a cross-institutional team to develop an area-wide sustainable integrated vegetation/ habitat management program for the Delta and critical tributaries.
- 2) Integrate this team into other Delta-wide management planning and conservation recovery efforts.
- 3) Obtain political and financial support to fund research and implementation efforts at the scale and duration required to establish a new vegetation balance within the Delta and a long-term sustainable management plan. This should include a combination of local, state and federal funding opportunities, including supporting Agencies such as BWWs, NASA and USDA-ARS.
- 4) Link this planning and implement effort with critical community-based information and decision support systems so that the public is informed, well served by this effort and involved in decision making processes.
- 5) Plan for and emphasize that in the long-term, water use fees should sustainably support such an effort and need to be linked with periodic reassessment of adaptive management goals and actions.
- 6) Design and implement a science-based assessment process to ensure that steps 1-5 are meeting public, private and environmental needs.